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International Space Station

Turning Science Fiction Into Science Fact

The creation and assembly of the International Space Station clearly demonstrates U.S. leadership of the global community, lighting the pathway for peaceful cooperation between nations in the 21st century. The largest international scientific and technological endeavor ever undertaken is taking shape 220 miles above Earth. With the Space Station, a permanent laboratory is being established in a realm where gravity, temperature, and pressure can be manipulated to achieve a variety of scientific and engineering pursuits that are impossible in ground-based laboratories. The Space Station will be a test bed for the technologies of the future and a laboratory for research on new, advanced industrial materials, communications technology, medical research and much more. On-orbit assembly has begun. A new star has appeared in the night sky, and it grows brighter as each international contribution is delivered to space.

Program

The completed International Space Station will be a permanent orbiting laboratory in space capable of performing long-duration research in the unique environment of Earth's orbit. The Space Station will:

- Sustain U.S. leadership of the global community
- Provide a platform for advances in science and technology
- Meet the deep-seated need of men and women throughout history to explore the unknown
- Enhance U.S. economic competitiveness and create new commercial enterprises
- Serve as a virtual classroom in space to the benefit of educators and students alike

Aboard this international orbiting laboratory, a broad range of research will take place. Astronauts from many nations will:

- Perform fundamental medical research, which could potentially benefit all humankind
- Develop new materials and processes to benefit industries on Earth
- Accelerate breakthroughs in technology and engineering that will have immediate, practical applications for life on Earth and will create jobs and economic opportunities worldwide.

On-orbit assembly of the Space Station began November 20, 1998, with the launch of the Russian-built Zarya (Sunrise) control module and will be complete in the 2005-2006 timeframe. The space station orbits Earth at an inclination of 51.6 degrees to the equator. This orbit has two advantages:

- It can be reached by the launch vehicles of all the international partners, providing a robust capability for the delivery of crews and supplies to the Station.
- It provides excellent Earth observation with coverage of 85 percent of the globe and over flight of 95 percent of the planet's population.

When complete, the Space Station will be 356 feet across and 290 feet long. It will weigh about a million pounds and will be able to house up to seven astronauts at one time.

The Shuttle-Mir Program

In preparation for the assembly and operation of the International Space Station, NASA and the Russian Space Agency entered into a cooperative program using the U.S. Space Shuttle and the Russian Space Station Mir. The main objectives for this international venture were to:

- Learn to work with Russia to overcome cultural difference.

- Reduce International Space Station construction and operations risks by testing designs and procedures

- Gain operation experience with long-duration missions

- Conduct research

When the Shuttle-Mir program ended in May 1998, the United States had continuous presence on Mir for almost 27 months. American astronauts who served a tour on Mir were Norm Thagard, Shannon Lucid, John Blaha, Jerry Linenger, Michael Foale, David Wolf, and Andy Thomas.

Shuttle-Mir Results

The Shuttle-Mir program provided the United States with the opportunity to conduct experiments in microgravity for periods of time far exceeding the two-week maximum of Space Shuttle flights. The flight of seven American astronauts and more than 140 experiments on Mir were an important step in preparing for Space Station assembly and research. The Shuttle-Mir science results include:

- **Microgravity Science**—Used cutting-edge technology to increase dramatically the number of protein crystals grown. Allowed for the significant expansion of in-flight tissue culture experiments from weeks to months. Benefited medical research on Earth with knowledge gained.

- **Life Sciences**—Collected significant data regarding human response to long-duration exposure to the microgravity environment ("weightlessness"). Discovered that bone loss does not lessen over time (1.2 percent of bone mass in the lower hip and spine is lost per month in microgravity).

- **Plant Growth**—Discovered that seeds from plants grown in space could be planted and seeds harvested, demonstrating that self-sufficiency for extended life sustenance in space is possible.

Day-to-day experience in space operations on Mir made clear to engineers that the design of certain areas of the International Space Station needed improvement. For example:

- Analysis of the events following the Mir fire resulted in a modification to the Station's software so that all intermodule ventilation can be shut off with a single command.

- Mir rendezvous and docking demonstrated that the planned use of the Shuttle "star trackers" requires the addition of Space Station track lighting.

The Development, Assembly, and Operations of the International Space Station

Creation of the International Space Station is underway. Much of the U.S. hardware scheduled to launch in the next two years is at the launch site at the Kennedy Space Center, FL, where it will undergo integration testing prior to launch. Continuing progress is being made on Space Station research, planning, and facility development. U.S. hardware deliveries include research racks scheduled for launch in 2001. It will take more than 90 U.S. and Russian space missions and more than a thousand hours of spacewalks to assemble the Space Station in orbit and maintain it.

Completed Missions:

- The first element, the control module Zarya (Sunrise), is a 20-ton, 43-foot-long module that contains propulsion, command, and control systems. It was built for NASA by the Russian corporation Krunichev, and it was launched on a Proton rocket from the Baikonur Cosmodrome in Kazakstan on November 20, 1998.

- Node-1, The first U.S. pressurized module of the Space Station, named Unity, was built at Marshall Space Flight Center and outfitted at Kennedy Space Center. It was launched from Kennedy on December 4, 1998, and was successfully joined to Zarya in space during Space Shuttle mission STS-88.

- In May 1999, an international crew of seven became the first visitors to the Station on Space Shuttle mission STS-96. As part of this first logisitcs mission, the crew outfitted the International Space Station for the arrival of its early living quarters and laid out a welcome mat for the first Station crew. Space Shuttle Discovery carried more than 3,600 pounds of supplies to be stored aboard the Station, ranging from food and clothes for the first crew to laptop computers, a printer, and cameras.

Upcoming Missions

Upcoming Space Station assembly missions include:

- Control Module Maintenance: A seven-member crew aboard Space Shuttle *Atlantis* will swap out batteries on the Zarya control module and take care of other lifetime issues, as part of STS-101.

- Service Module: The Russian Service Module named Zvezda (Star) will be launched from Khazakstan aboard a Russian proton rocket and remotely docked to the Station. The Service Module will serve as an early station living quarters and provide life support system functions to early Station elements. It also serves as the primary docking

port for Russian cargo resupply vehicles and provides reboost and attitude control capabilities.

- Service Module Outfitting: During STS-106, Space Shuttle *Atlantis* will carry logistics and supply cargo for outfitting the Service Module. It will also carry the Russian Strela crane telescopic boom to be attached to the Station's exterior and used for future Station assembly. The astronaut crew will perform orbital checkout and setup of the Service Module.

- Truss Structure: As part of STS-92, the Space Shuttle *Discovery* will carry part of the integrated truss structure to the station. This framework, the backbone of the International Space Station, will allow for the installation of the first solar arrays for early power to the Station. In addition, the mission will install a Ku-band communications system, control moment gyros, which will provide electrically powered attitude control, and a docking port that will be used during solar array installation.

- First Crew: A Russian Soyuz rocket will carry the first international crew of three, comprised of Commander Bill Shepherd, Soyuz Commander Yuri Gidzenko and Flight Engineer Sergei Krikalev. This will mark the beginning of permanent human presence aboard the Station. The Soyuz spacecraft will dock with the station, providing emergency crew return capability. The crew will remain on the Station for about three months.

- First Solar Power: During STS-97 the Space Shuttle *Endeavour* will provide the first solar arrays and batteries, as well as cooling systems. Also the S-band communications system will be activated for voice and telemetry.

Partner Contributions

Countries participating in the International Space Station program are Canada, Japan, Brazil, Russia, and 11 nations of the European Space Agency. Highlights of the partners' contributions include:

- NASA, the U.S. space agency, is the initiator, integrator and leader of the International Space Station effort. U.S. hardware contributions include the truss structures that provide the Station's framework, four pairs of large solar arrays, three nodes with ports for spacecraft and for passage to other ISS elements, and an airlock that accommodates U.S. and Russian space suits. NASA is also providing the U.S. laboratory, and habitation and centrifuge accommodation modules. In addition, NASA will provide power, communications and data services, thermal control, environmental control and life support, and crew health maintenance. NASA is also developing the X-38, a prototype for a future crew return vehicle for the Station.

- Russia is providing about a third of the mass of the Space Station, including research modules, a service module with its own life support and habitation systems and a science power platform that supplies about 20 kilowatts of electrical power. They also are providing logistics transport using Progress vehicles and Soyuz spacecraft crew rotation. In addition, the Mission Control Center in Moscow will provide primary command and control of the Space Station until the U.S. Lab is docked on mission 5A.

- The European Space Agency is providing the Columbus Orbital Facility, which includes pressurized laboratory and external payload accommodations. The space agency also is providing logistics transport vehicles to be launched on the Ariane V launch vehicle.

- Canada is providing the Mobile Servicing System which includes a 55-foot-long robotic arm along with a smaller manipulator attachment, to be used for assembly and maintenance tasks on the Space Station, as well as a Mobile Remote Servicer Base, which allows the robotic arm to travel along the truss.

- Japan is providing an on-orbit faculty named Kibo that includes a pressurized laboratory, a Logistics Module, and an attached facility exposed to the vacuum of space serviced by a robotic arm. Japan is also providing logisitic resupply using the HII launch vehicle.

- Brazil is providing a pallet to house external payloads, unpressurized logistics carriers, and an Earth observation facility.

Future Activities: Science Operations and Commercialization

The Space Station will provide scientists the electric power and laboratory space on orbit to conduct the research that could contribute to safe, long-term space exploration by human beings. The knowledge gained will also benefit research on Earth in many fields. Areas of research currently planned for the International Space Station include biotechnology, materials science, combustion science, gravitational biology, advanced human life support, Earth observation, space science, physics, and engineering research and technology. The list is endless.

Research activities will begin during the assembly process, with many initial research capabilities available in 2000. Also, NASA has recently completed a Commercial Development Plan that will provide a framework for allowing private companies to conduct research on the Station. In addition, NASA is reviewing the possibility of forming a non-governmental organization to manage utilization of the Station and commercial development.

Summary

The International Space Station is under way. The newest star in the night sky will continue to grow bright, demonstrating to the world that nations can work together on peaceful initiatives that will benefit the entire global population.